# 1-D Transient Thermal Modeling of an Ablative Material (MCC-1) Exposed to a Simulated Convective Titan IV Launch Environment

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# OUTLINE

- Introduction
- Testing
- Transient Thermal Analysis
- Results
- Summary and Conclusions

# INTRODUCTION

Purpose of work is to demonstrate flat test panel substrate temperatures consistent with analysis predictions

Testing performed in aerothermal facility

MCC-1 on aluminum substrate

# Testing

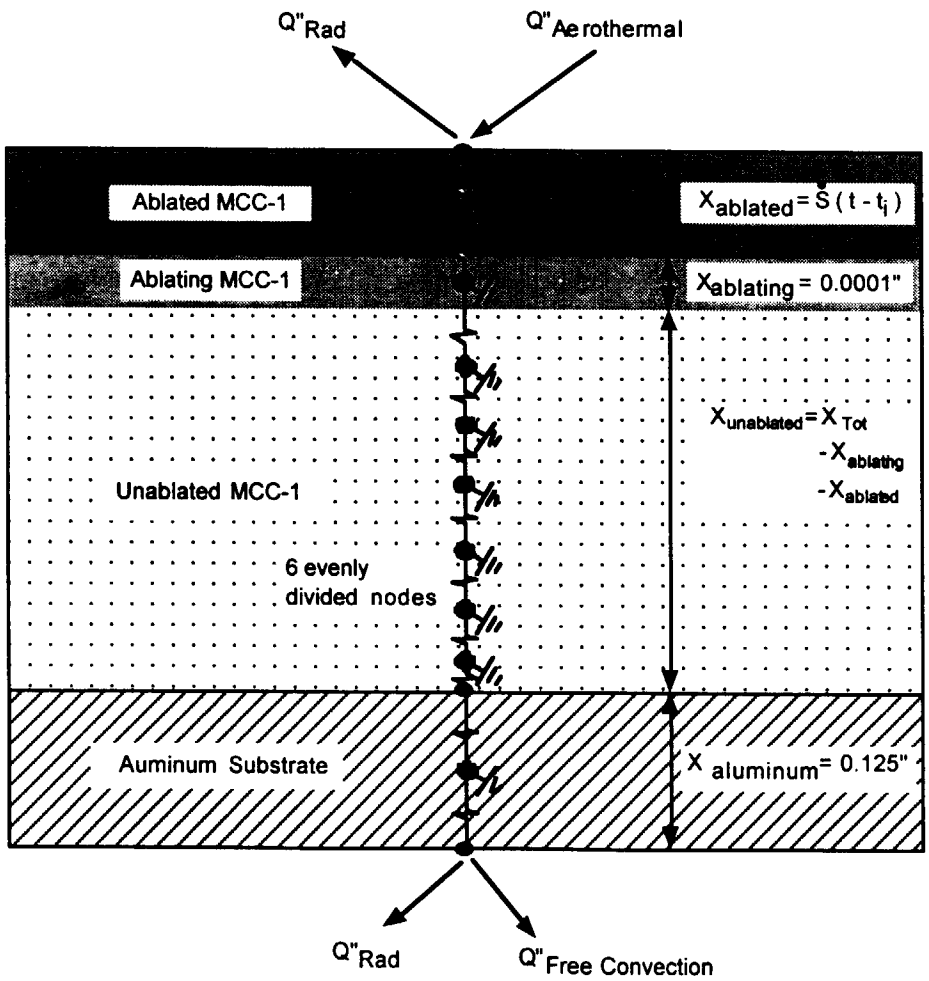
- Performed in IHGF facility
- Calibration runs define aerothermal heating environment
- Three different MCC-1 thicknesses tested

# TESTING (Continued)

## Bare MCC-1 Test Matrix

| Test Series | Cold Wall Heat Flux ($Btu/s/ft^2$) | Test Run Length (s) | Aluminum Substrate Thickness (in) | MCC-1 Thickness (in) |
|---|---|---|---|---|
| T96-690 | 4.6 | 114 | 0.125 | 0.158 |
| T96-693 | 4.6 | 114 | 0.125 | 0.158 |
| T96-697 | 4.6 | 114 | 0.125 | 0.056 |
| T96-699 | 4.6 | 114 | 0.125 | 0.056 |
| T96-684 | 4.6 | 200 | 0.125 | 0.344 |
| T96-686 | 4.6 | 200 | 0.125 | 0.343 |

# TRANSIENT THERMAL MODEL



# TRANSIENT THERMAL MODEL (Continued)

- Key assumptions

  ⇒ 1-D heat transfer
  ⇒ Constant ablation recession rate (determined from pre- and post-test measurements)
  ⇒ Ablation temperature 540°F
  ⇒ Char left behind ablation front
  ⇒ Temperature Jump Correction for Incident Heat Transfer Coefficient

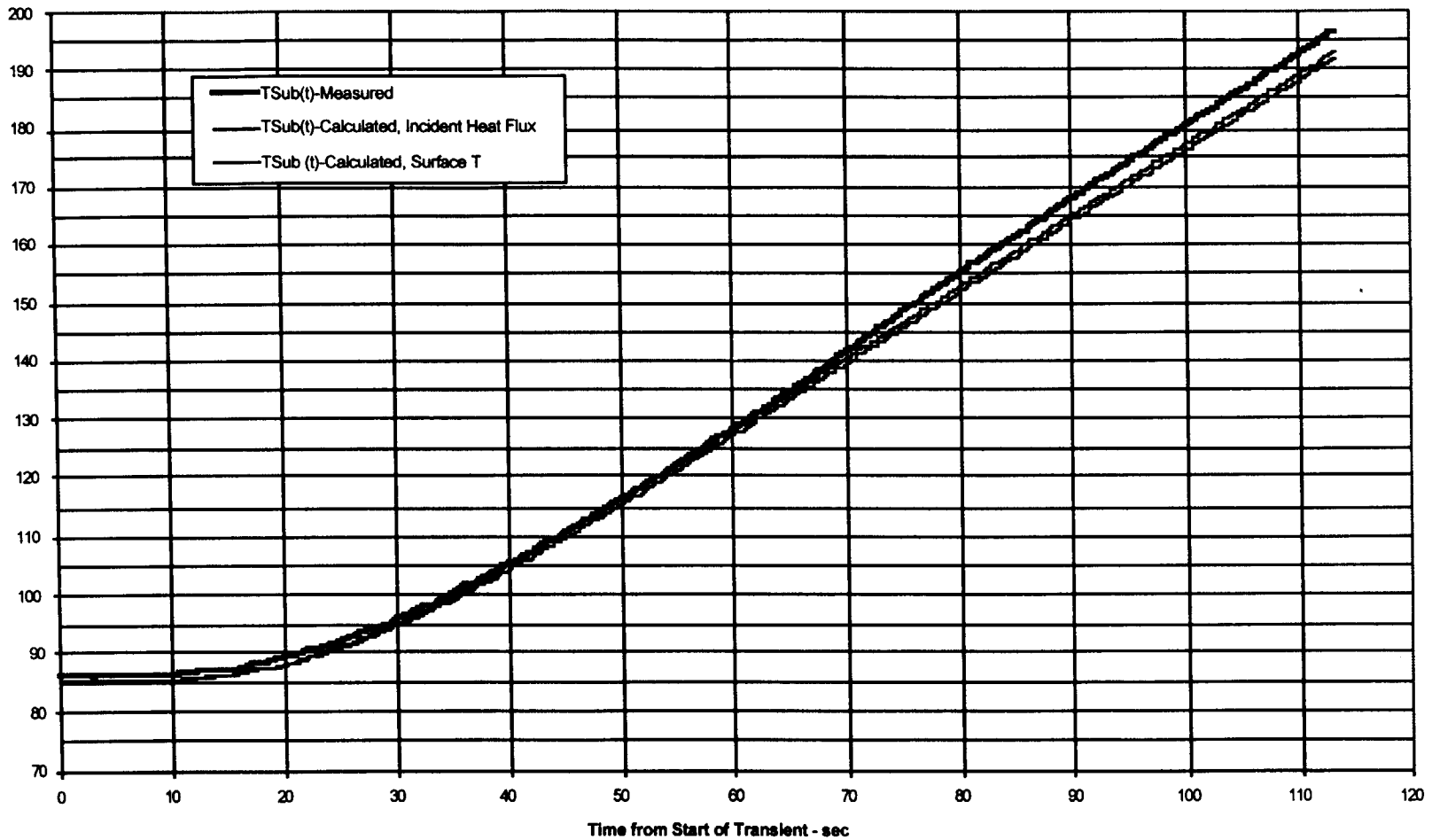
# TRANSIENT THERMAL MODEL (Continued)

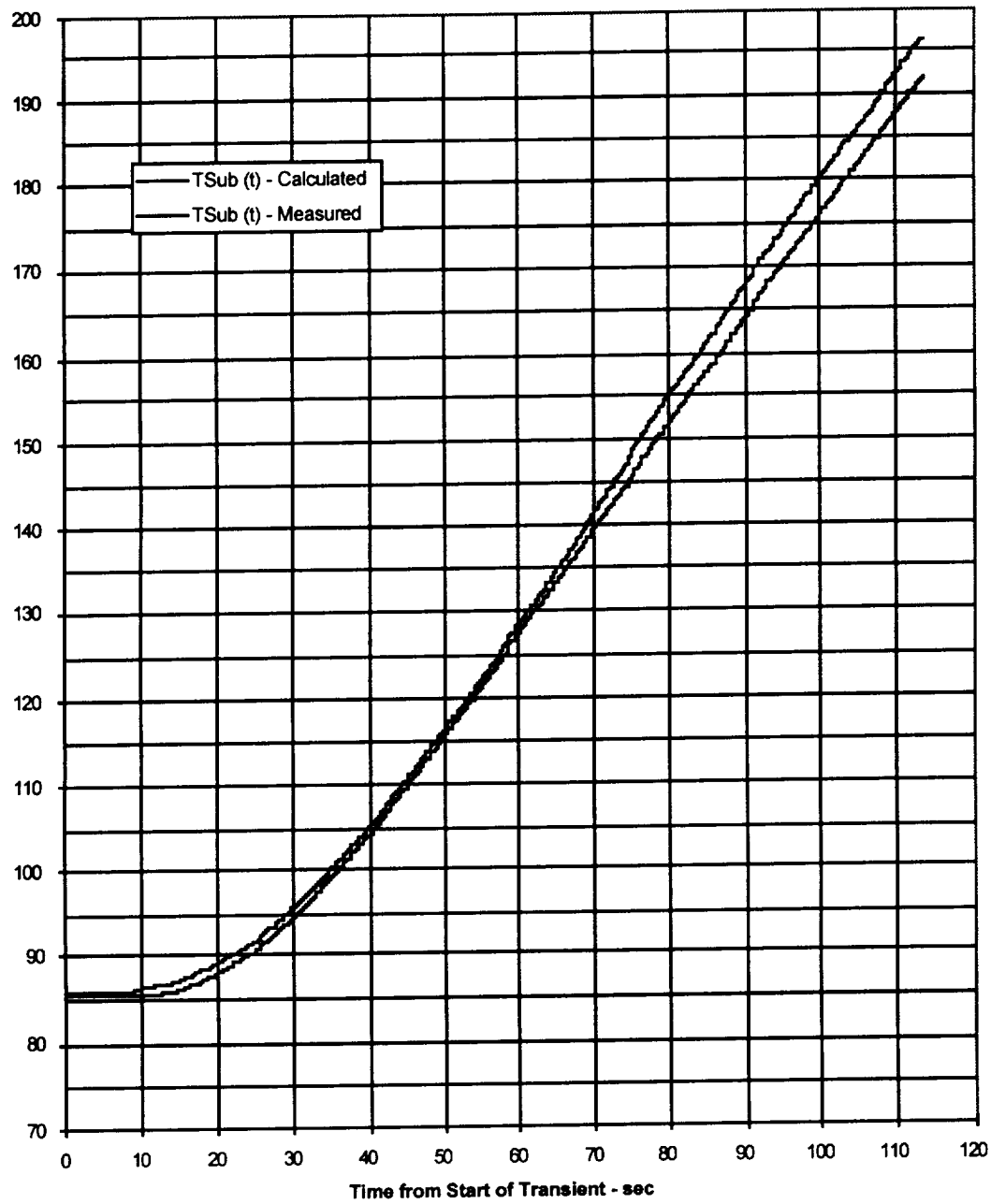
- Two Methods Used to Model Heating of Bare MCC-1

  ⇒ Directly Input Surface Temperature as a Function of Time, $T_S(t)$, from IR Measurement

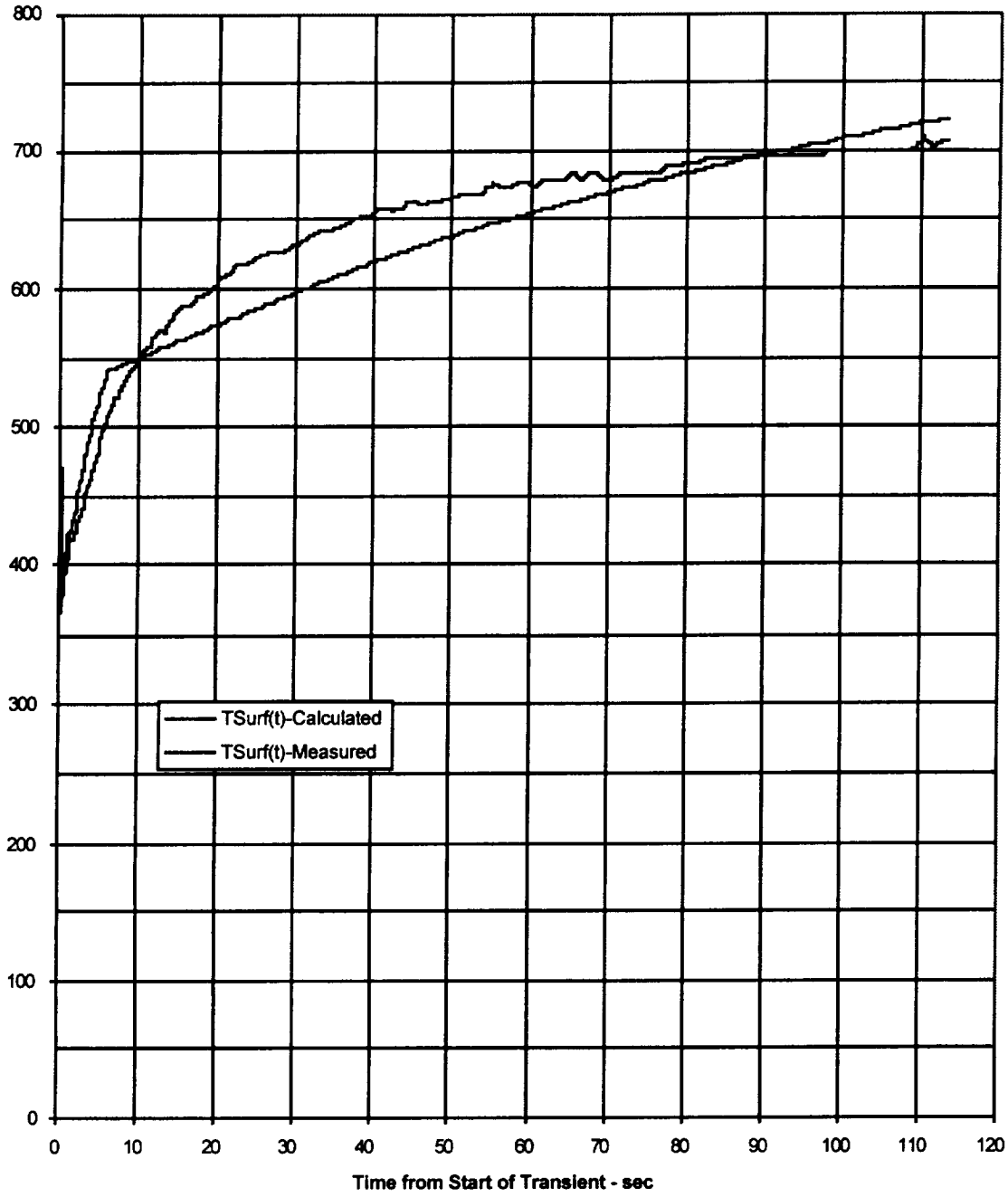
  ⇒ Aerothermal Heating Using Calibration Plate Data, Subtracting Radiation Losses to Tunnel Walls

# RESULTS

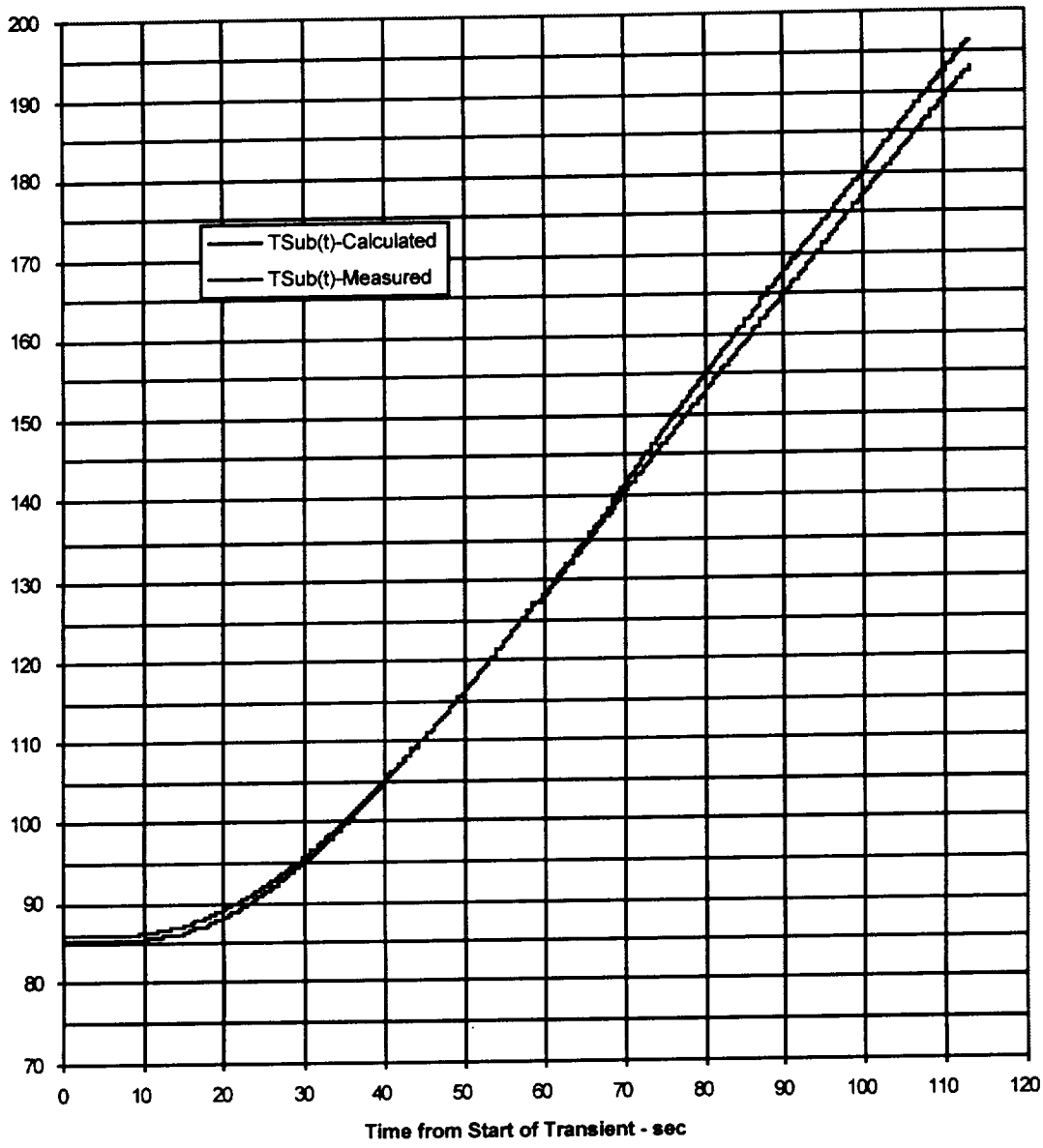

TSub(t)-Measured
TSub(t)-Calculated, Incident Heat Flux
TSub (t)-Calculated, Surface T
200
190
180
170
160
150
140
130
120
110
100
90
80
70
0
10
20
30
40
50
60
70
80
90
100
110
120
Time from Start of Transient - sec



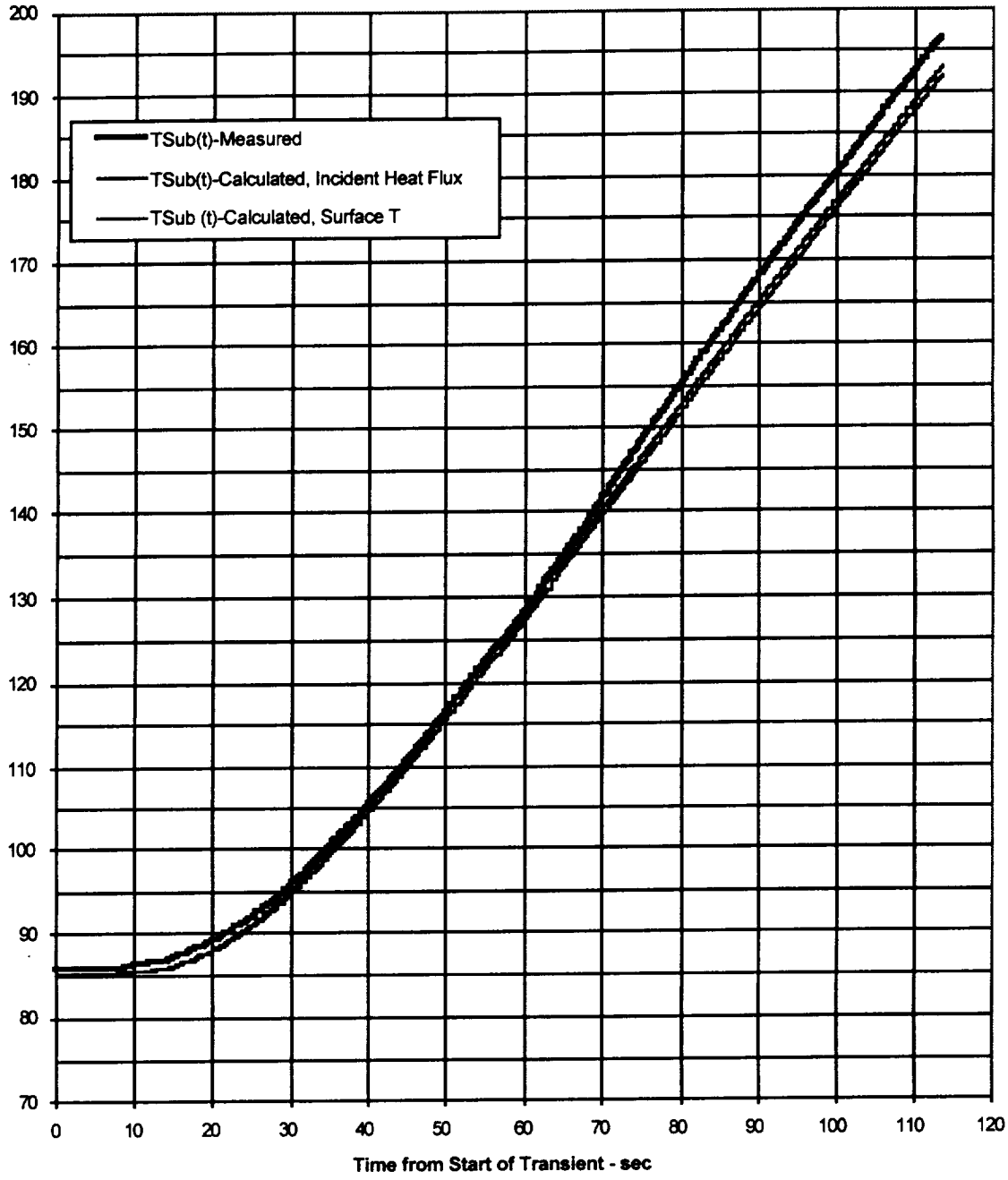

**Comparison of $T_{sub}$ (t) Measured and Predicted Values with Imposed $T_{surf}$ (t) Boundary Conditions ( $q''_{CW}$ = 4.6 Btu/s/ft$^2$, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)**



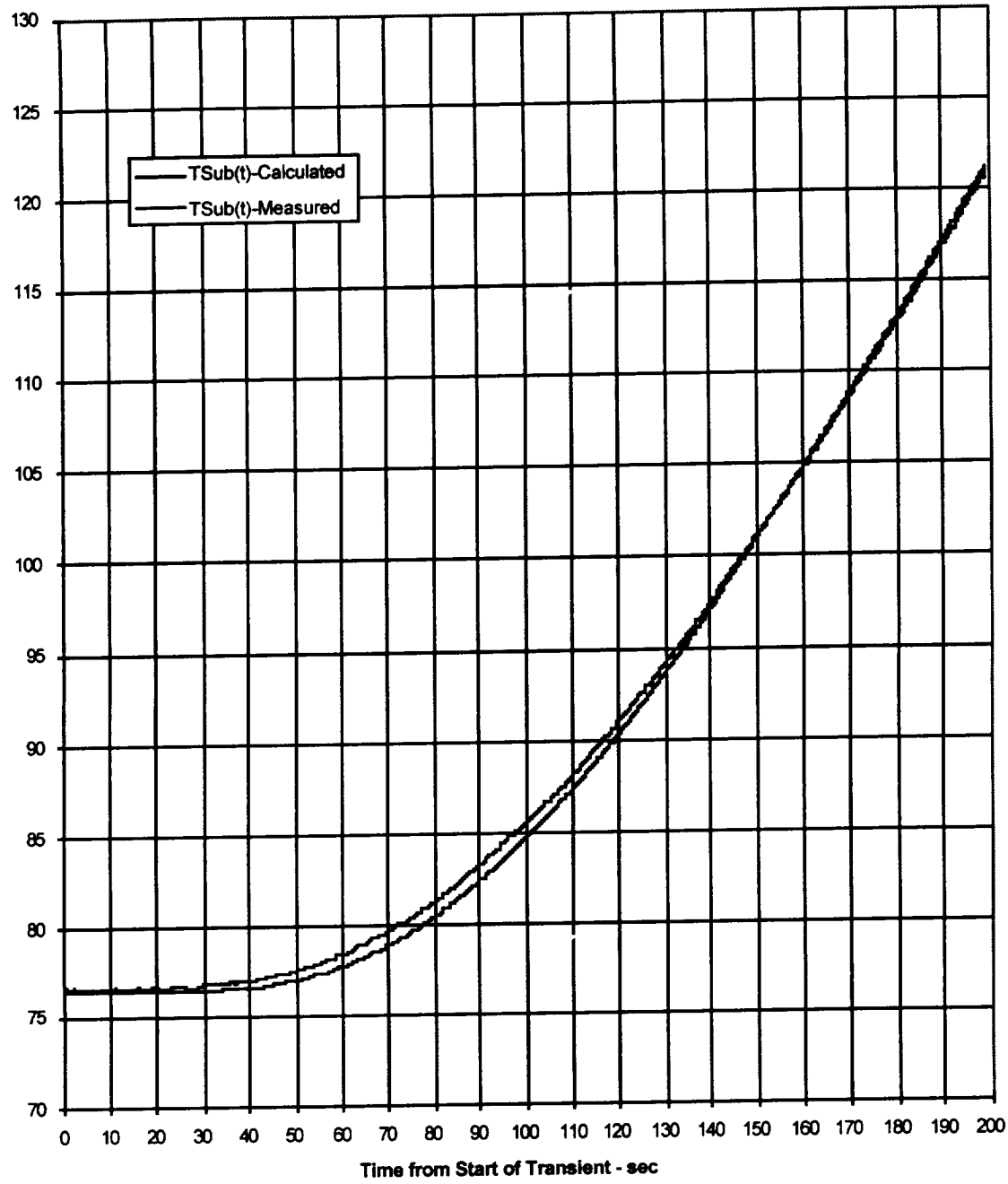

**Comparison of $T_{surf}$ (t) Measured and Calculated Values with Incident Heat Flux Conditions Specified from Calibration Testing**
**( $q''_{CW}$ = 4.6 Btu/s/ft$^2$, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)**



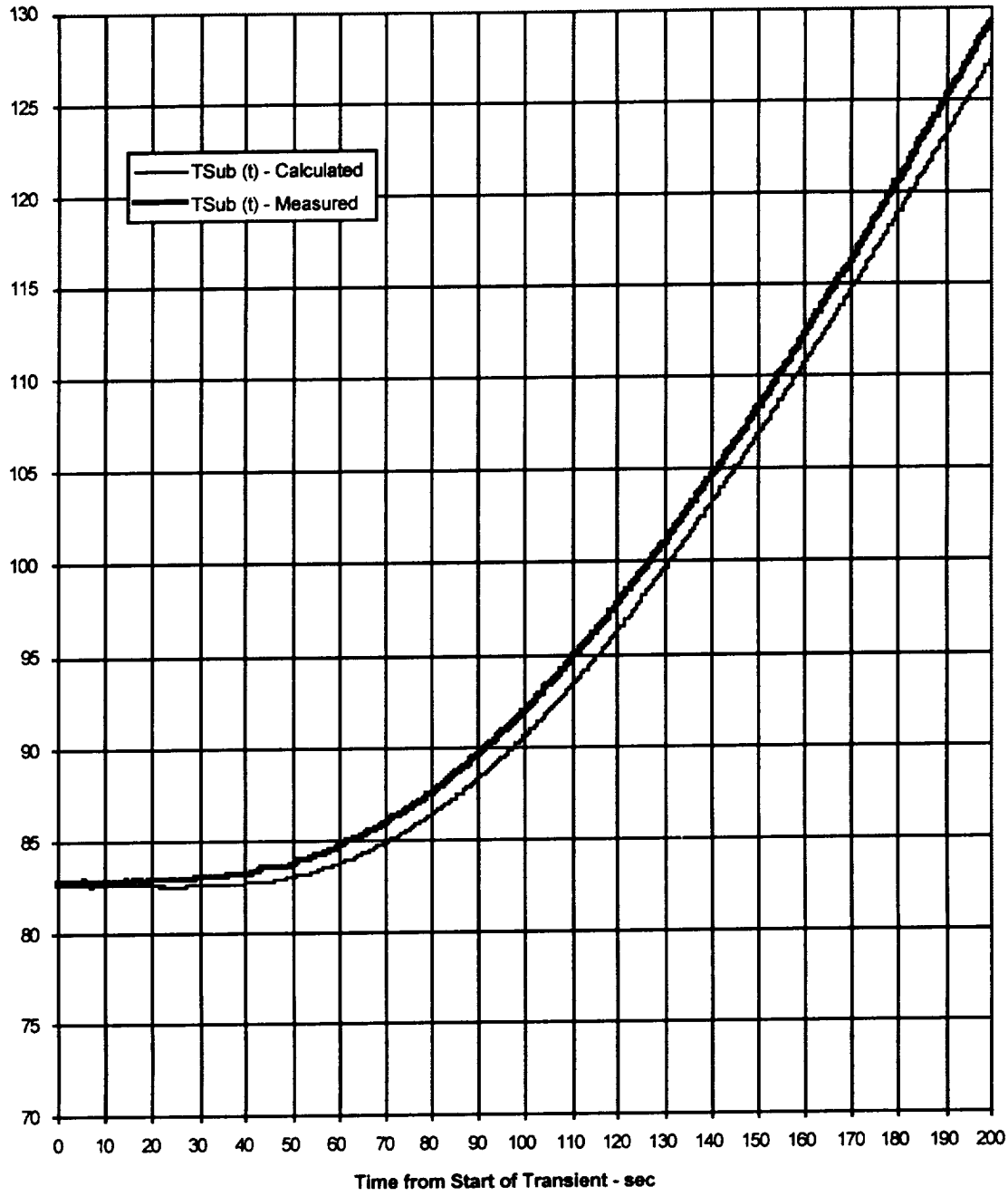

**Comparison of $T_{sub}$ (t) Measured and Calculated Values with Incident Heat Flux Conditions Specified from Calibration Testing ( $q''_{CW}$ = 4.6 Btu/s/ft$^2$, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)**



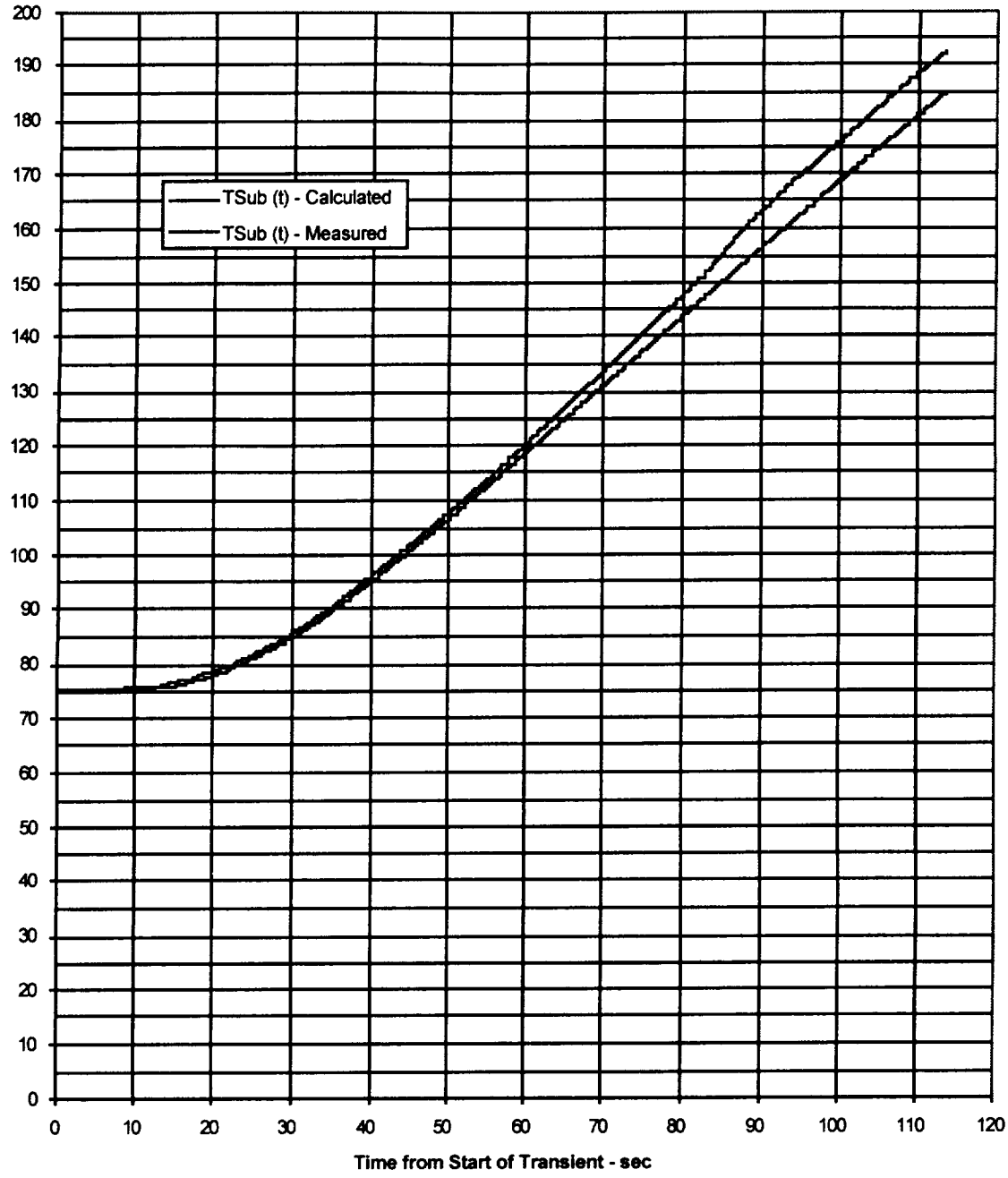

**Comparison of Predicted Aluminum Substrate Temperatures Using Both the Imposed $T_{Surf}$ (t) and the Incident Heat Flux Boundary Conditions**
**( $q''_{CW}$ = 4.6 Btu/s/ft$^2$, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)**




**Comparison of $T_{sub}$ (t) Measured and Calculated Values with Incident Heat Flux Conditions Specified from Calibration Testing**
**( $q''_{CW}$ = 4.6 Btu/s/ft$^2$, Al thickness = 0.125 in., MCC-1 thickness =0.344 in.)**




**Comparison of $T_{Sub}$ (t) Measured and Calculated Values for Incident Heat Flux Conditions Specified from Calibration Testing**
**( $q''_{CW}$ = 4.6 Btu/s/ft$^2$, Al thickness = 0.125 in., MCC-1 thickness =0.343 in.)**




**Comparison of $T_{Sub}$ (t) Measured and Calculated Values Incident Heat Flux Conditions Specified from Calibration Testing**
**( $q''_{CW}$ = 4.6 Btu/s/ft$^2$, Al thickness = 0.125 in., MCC-1 thickness =0.158 in.)**